CR 91.012

NCEL

Contract Report

September 1991

SOIL BIOENGINEERING
CORPORATION
MARIETTA, GA

SOIL BIOENGINEERING MAJOR GULLY WASHOUT REPAIR, SILVERHILL AIRFIELD, BALDWIN COUNTY, ALABAMA

ABSTRACT This report summarizes research conducted at Navy sites affected by gully erosion. Soil bioengineering (or biotechnical) techniques were used to repair and stabilize a large gully located at Silverhill OLF, Alabama. Biotechnical methods included brush layering, branch packing, live stakes, and live cribwalls. A portion of the project site used more conventional methods of slope stablization for a side-by-side comparisons of their effectiveness. Despite drought conditions subsequent to installation, survival rate was high enough to initially stablize the site. Subsequent monitoring of the site is recommended to determine long-term effectiveness. This investigation indicates promising use of biotechnical methods for slope stablization and gully repair under various conditions.

NAVAL CIVIL ENGINEERING LABORATORY PORT HUENEME CALIFORNIA 93043

METRIC CONVERSION FACTORS

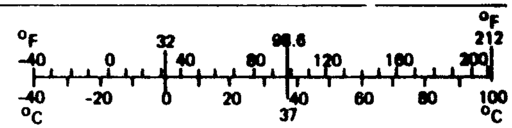
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13 10 286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Ms. Leslie Karr, Environmental Engineer, Naval Civil Engineering Laboratory, Port Hueneme, California

Lt. Anthony Cox, Resident Officer in Charge of Construction, Pensacola, Florida

Mr. Andy Johnson, Soil Conservationist, Southern Division, Naval Facilities Engineering Command, Charleston, South Carolina

Soil Bioengineering Corporation wishes to extend its sincere appreciation to Dr. Hugo Schiechtl, Soil Bioengineer/Landscape Architect, Innsbruck, Austria, for his personal support and for his continuing professional dedication to the development of soil bioengineering.

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Soil Bioengineering Technology Utilized to Repair Gully Erosion on OLF Silverhill Baldwin County, Alabama

INTRODUCTION

The Naval Civil Engineering Laboratory (NCEL), Port Hueneme, California, in coordination with Southern Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), Charleston, South Carolina, the U.S. Dept. of Agriculture, Soil Conservation Service (SCS), Auburn, Alabama, and Soil Bioengineering Corporation, Marietta, Georgia, developed soil bioengineering/biotechnical land stabilization procedures in combination with conventional engineering design features. These steps were taken to stabilize the headcut erosion on the side walls, the head walls and channel floor of an actively eroding gully. The site was a large, heavily eroded gully approximately fifteen hundred (1,500) linear feet long, approximately forty (40) feet deep, with twenty (20) to one hundred (100) foot bed widths. The erosion was progressing rapidly in the side face areas where secondary gully headcuts were encroaching onto privately owned property. The erosion was jeopardizing a previously constructed drop structure and producing heavy sediment loads to be deposited "downstream".

The site is located at the OLF Silverhill airfield in Baldwin County, Alabama.

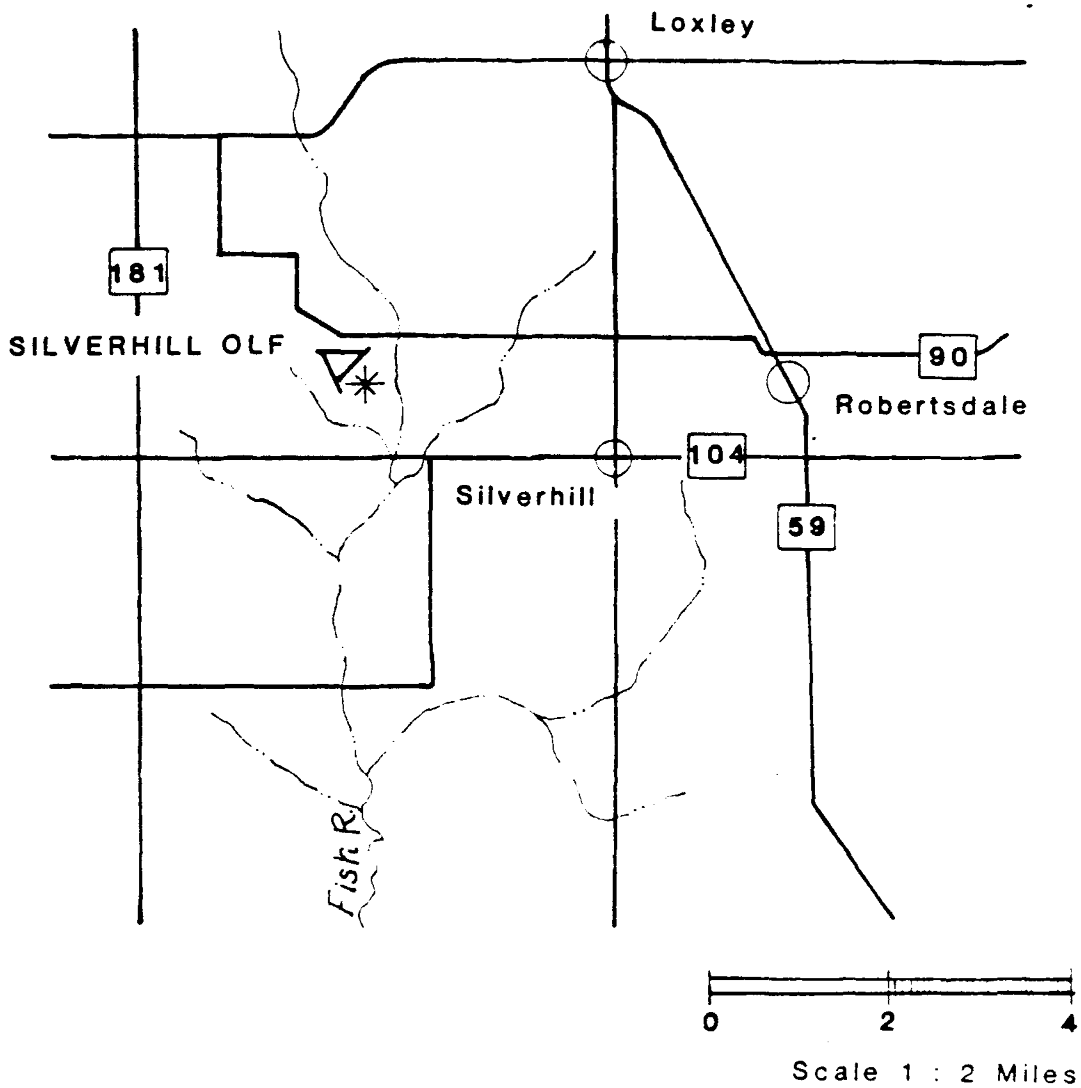
PURPOSE

The main purpose of this limited evaluation report is to provide the Department of the Navy with an understanding of the history, site conditions and merits of soil bioengineering technology as it applies to this project site. Before, during and after construction photographs and slides are also included for reference.

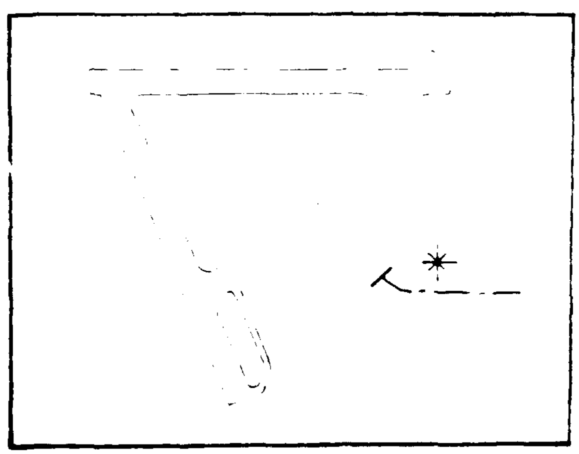
The broad objective of this work was to test and demonstrate a designed and constructed soil bioengineering/biotechnical land stabilization project, specifically to repair and prevent problems associated with soil erosion on the Silverhill site.

The site was chosen by the Navy and used as a demonstration in support of the biotechnical systems, to learn the methods by which such a project is developed. Methods discussed and demonstrated were: tender/bidding this technology to outside contractors, overseeing correct controlled project management, collecting, handling, and installing procedures, and maintenance evaluation performance. The eventual goal, after several such tests/demonstrations, is for the Department of the Navy to benefit from using rapid repair and stabilization techniques offered by soil bioengineering technology on Navy sites.

This report also addresses the system of the tender/bid process as it was handled on this project, and the adequacy of the construction techniques used by the construction contractor. It identifies and discusses stressed areas of unsatisfactory biotechnical installations and suggests possible repairs. The document fully discusses the success of each system installed. Finally, it discusses the Navy's support and administration of the construction process.



LOCATION MAP
SILVERHILL OLF



✳ Designates Study Site

SOIL BIOENGINEERING

A soil bioengineering approach offers many advantages to soil stability: 1) actual field studies have shown that in many instances combined structural-vegetative slope protection systems are more cost-effective than the use of structures alone (White, 1979); 2) soil bioengineering slope protection systems are more aesthetically pleasing, i.e., they blend into the landscape; 3) these systems emphasize the use of natural, locally available materials - earth, rock, timber, vegetation; and 4) soil bioengineering systems, by their live nature, offer flexible self-repairing qualities, which contribute to low long-term maintenance.

The use of vegetation, primarily grasses and forbs, for preventing surface erosion on land sites, is fairly common and well understood. The U.S. Soil Conservation Service and similar government agencies around the world have long advocated plantings to control both rainfall induced surface erosion and wind erosion. However, the protection provided by this herbaceous vegetation is primarily shallow in nature, as the developed root masses rarely penetrate more than a few inches into the soil. It can indirectly benefit deep-seated, mass stability by depleting soil moisture, and stabilizing the soil against surface erosion, facilitating the establishment of shrubs and trees (Gray and Leiser, 1982). The "bottom" or "bed" section of the gully had (in certain areas) a well developed grass cover.

Woody plants help prevent mass-movement, particularly shallow sliding. Soil bioengineering woody plant installation affects immediate sedimentation/soil stabilization. These initial mechanically functioning systems encourage a high percentage of seed germination and rapid natural invasion of plants well adapted to the site conditions. Woody vegetation affects the balance of forces in a soil mass through root reinforcement, evapotranspiration, and buttressing and arching, whereby anchored and embedded stems can act as buttress piles or arch abutments in a slope, counteracting shear stresses. Specific instances where trees were serving as buttress units on this site were readily available during the initial site visits.

Root reinforcement is the most obvious way in which woody vegetation stabilizes soils. The intermingled, lateral roots of plants tend to bind the soil together into a monolithic mass. On slopes, the vertical root system can penetrate through the soil mantle into the firmer strata below, thus anchoring the surface soils to the slope and increasing resistance to sliding.

Vegetation, alone, can not control all erosion/sedimentation movements. Site specific characteristics must be considered in the decision to use vegetation singularly or in conjunction with conventional structures. In the case of OLF Silverhill, the combination of soil bioengineering with conventional engineering was expected to produce the best overall structures. The conventional works are intended to give immediate reduction to the velocity of the flood waters, while the soil bioengineering systems, as they grow, are expected to consolidate the soil particles, reduce heavy runoff water velocity by increasing the top vegetative growth, and retain and trap sediment deposits along the banks.

DESCRIPTION OF OLF SILVERHILL

OLF Silverhill:
Baldwin County, Alabama

The project site was a large undulating, heavily eroded gully, formed by collected water run-off. The headwall had been partially restrained from erosion by a sheetpile grade structure. The reconstructed gully drainage channel and side slope area is approximately fifteen hundred (1,500) linear bank feet. The existing vertical banks, prior to construction, ranged from five (5) feet to approximately forty (40) feet in overall height at the gully headwall. The floor or bed width ranged from twenty (20) feet wide in the lower "downstream" sections to one hundred (100) feet wide in the upper reaches.

There were several major side slope cut and fill sections, with the Soil Conservation Service (SCS) channel alignment and drop structure designs, below the existing grade structure. The area immediately adjacent to this was installed with conventional methods designed by the SCS.

Soil bioengineering systems "tied into" the area with live systems to join the required conventional structure to the live "downstream" work, as well as to serve as a back up to the conventional construction. The floor, or bed, of the gully was first mechanically stabilized with two (2) additional drop structures, which were designed by the SCS. In between the drop structures, soil bioengineering living systems were put in place in the channel bed. These are expected to further reduce velocities and cause deposition to occur in the bed.

The sides of the gully have been stabilized with living soil bioengineering units. These are intended to control surface erosion, consolidate the soil particles and add fibrous inclusions to increase the shear strength of the soils and to resist sliding.

Climate

Information for climate, physiography, and soils was interpreted from U.S.D.A. Soil Conservation Service Soil Surveys of Baldwin County (1960).

Baldwin County has a humid, nearly subtropical climate. The long, hot summers are tempered by sea breezes making the average summer temperature 80.2 degrees. The high temperatures

prevent a large amount of organic matter from building up in the soils. Average annual rainfall is normally high, 64.6 inches, and well distributed throughout the year. However, over the last two (2) or three (3) years, springs and summers have been much drier than normal. Considering the humid climate and the normally even distribution of rainfall, the site appeared to be well suited for biotechnical stabilization work.

Physiography and Soils

Baldwin County is a part of the Gulf Coastal Plain physiographic region. The Silverhill site is underlain by Citronelle geologic formation which rests on Hattiesburg clay. The material in the Citronelle formation is predominantly sandy with thin layers of clay. The sand is red and crossbedded, the clay mottled gray and red. Most of the Citronelle formation in the county has been impacted by erosion.

The soil phase at the Silverhill site is Lakeland loamy fine sand, 8 to 12 percent slopes. The soils are low in natural fertility and in organic matter content. The soil texture includes sand, loamy sand and very fine loamy sand. The water storing capacity of this soil is low. Water infiltrates rapidly and the hazard of erosion is moderate to severe.

As waters drain into the Silverhill gully from the watershed, rapid infiltration causes the banks to become saturated during periods of high rainfall. As waters quickly drain through the banks, unconsolidated sands are removed by the waters, causing bank failure.

Biotechnical Plant Materials

Plant species used for the live stabilization systems included both woody and herbaceous vegetation. Plant selection was based on the technical requirements, ecological suitability, and availability of appropriate stock in the local area. A mixture of species was used to assure the greatest technical effectiveness by providing a diverse root system as well as encouraging the ecological health associated with a diverse plant community. Selected woody species were native or naturalized to the surrounding area and thus were expected to be well adapted to the local growing conditions. Herbaceous species were a mix of grasses and legumes well adapted to local conditions and commercially available.

The Silverhill site showed evidence that vegetation may be able to establish itself if conditions were modified through grading, proposed by the Soil Conservation Service, combined with soil bioengineering systems. In areas where rapid soil movement was not occurring, the invasion of natural species was readily apparent.

Woody Species

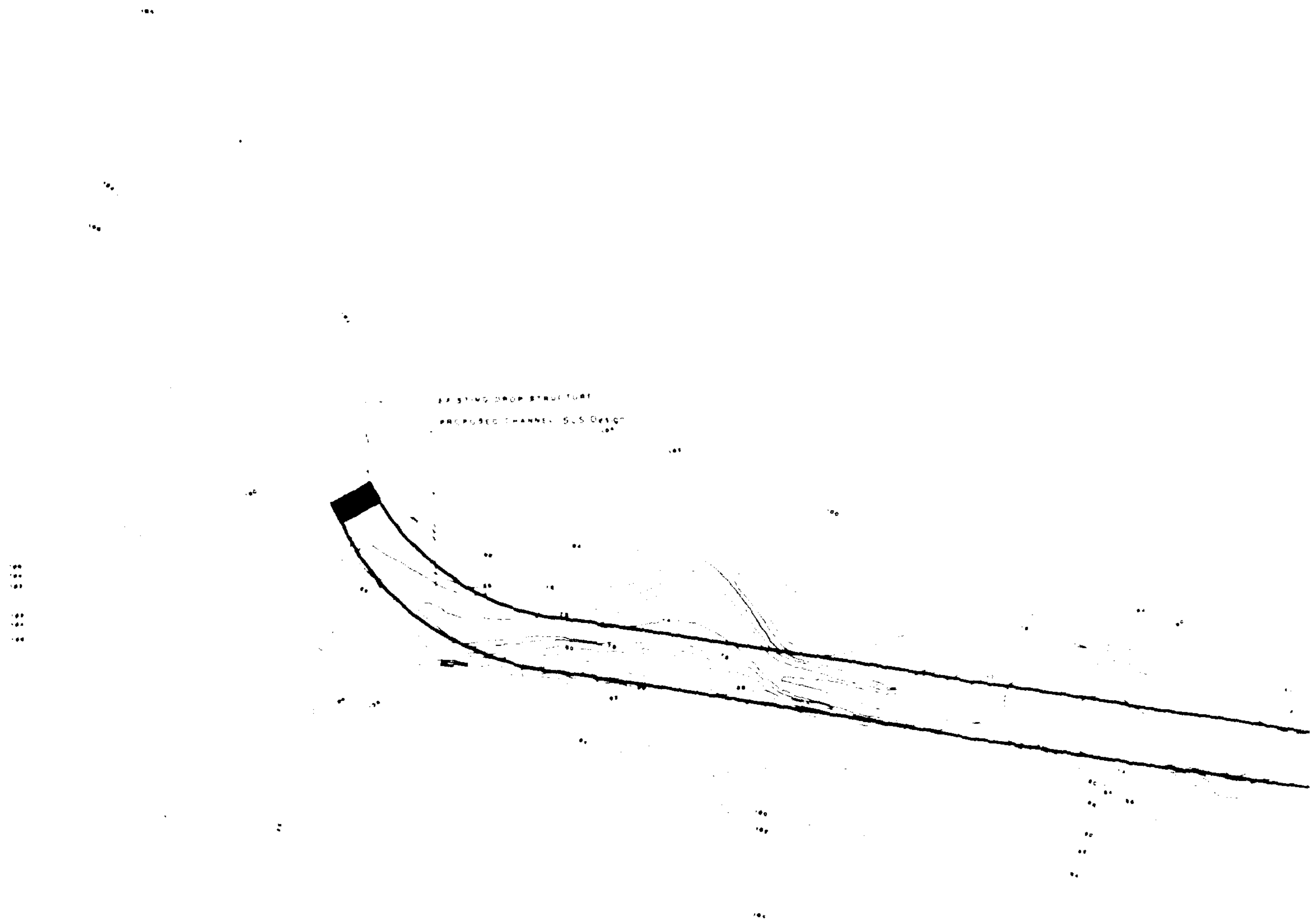
On the Silverhill site, it was expected that several woody species would provide the major structural support at the time of installation: black willow (Salix nigra), coastal plain willow (Salix caroliniana), and Chinese privet (Ligustrum sinense). Experience has shown that unrooted cuttings of most willow and privet species root well when handled and installed correctly in biotechnical systems.

A major investigation was conducted for plant collection sites within a sixty 60 mile radius of the site. Chinese privet was found in lowlands or on fence rows in agricultural areas. Adequate stands of willow species were found to fulfill the project requirements.

A relatively high species mix of grasses and legumes was developed by the SCS, for seeding after installation and between the woody biotechnical systems. This mix may assist in stopping surface erosion and improving fertility and organic matter content. The species mix plays an important initial role and should not become either competitive or invasive. The ultimate goal is the natural invasion of native species, which is expected to occur over a period of years. The system is not initially strong, but is intended to become more effective and stronger with age.

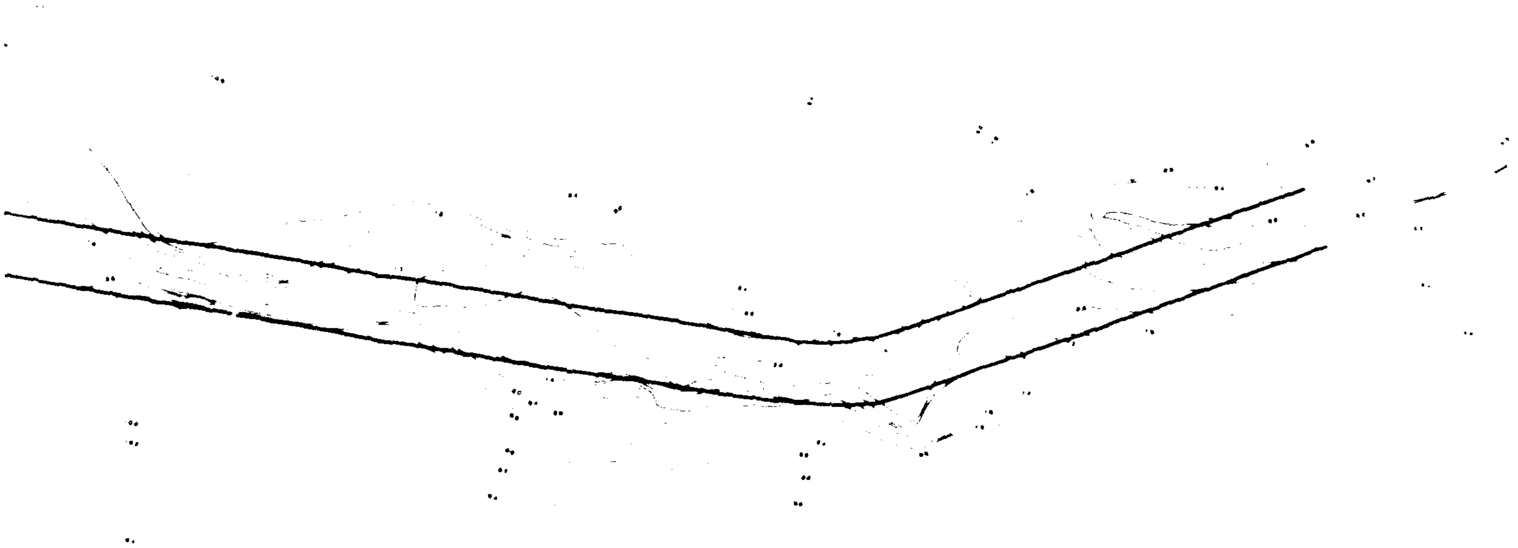
The biotechnical systems were constructed and seeding performed mainly during the dormant season. The seed mixture consisted of the following commercially available species: Pensacola bahiagrass (Paspalum notatum), bermudagrass (Cynodon dactylon), Abbruzzi ryegrass (Lobium multiflorum), and Tibbee crimson clover (Trifolium incarnatum). The appropriate inoculant was also recommended with the clover species. It is expected that each species will have varying survival rates depending on the local micro climatic growing conditions. In particular, clovers have a limited long-term survival rate but help in "fixing" nitrogen and contributing organic matter to the soil.

The herbaceous cover holds importance in limiting surface erosion during the first months in conjunction with the woody biotechnical systems. The seed mix density needed to be limited to insure that the surrounding area was not inhibited. Fertilizing, liming, and mulching recommendations were made after evaluation of the soil analysis. Two (2) types of fertilizer, 13-13-13 and 17-7-12 (slow release), were used during the construction of the soil bioengineering systems.



MAJOR GULLY STABILIZATION USING SOIL BIOENGINEERING TECHNOLOGY

TOPOGRAPHIC PLAN VIEW
WITH THE PROPOSED CHANNEL
SCS DESIGN



MAJOR GULLY STABILIZATION USING SOIL BIOENGINEERING TECHNOLOGY

TOPOGRAPHIC PLAN VIEW

WITH THE PROPOSED CHANNEL

SCS DESIGN

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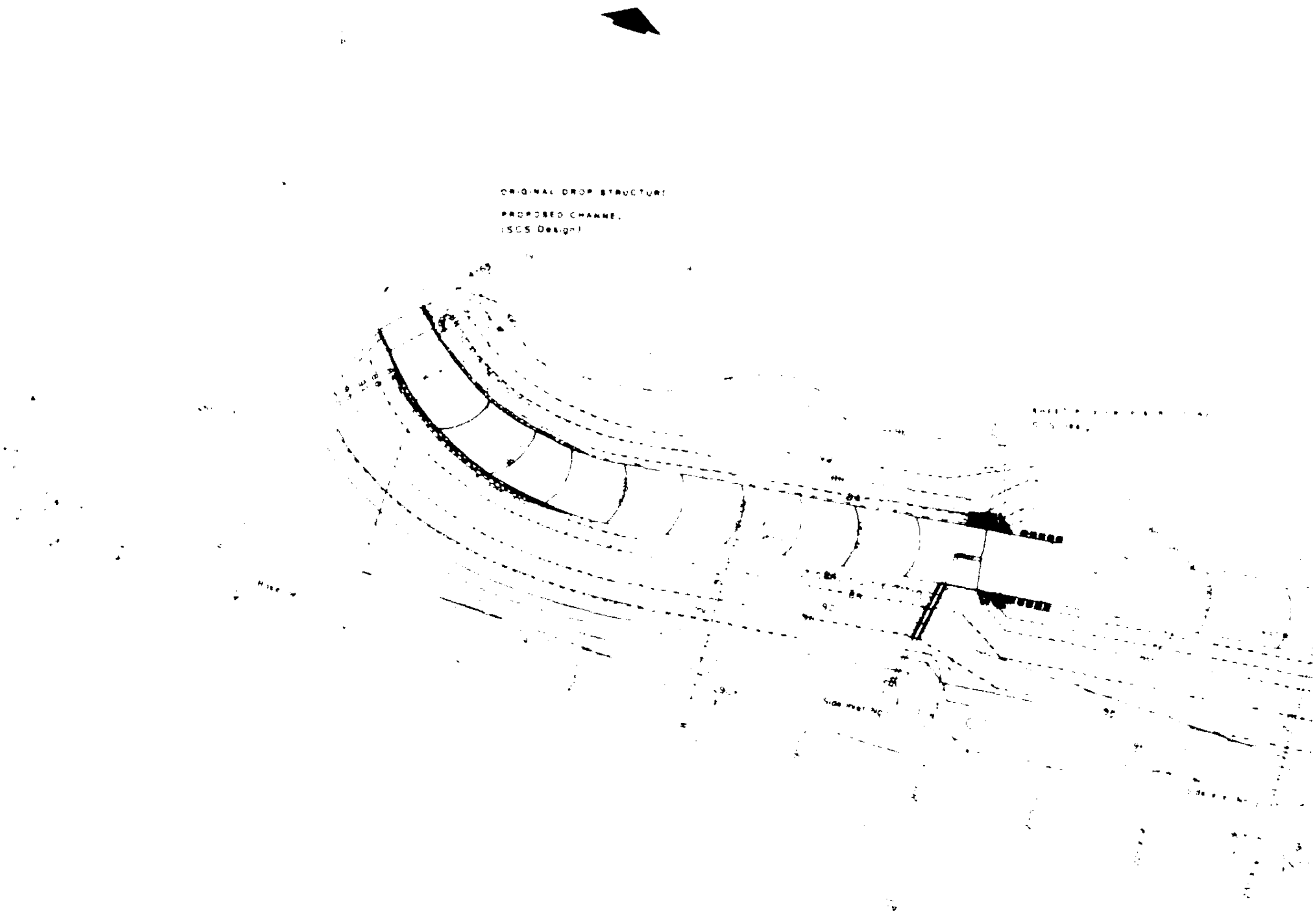


MAJOR GULLY STABILIZATION USING SOIL BIOENGINEERING TE

PROPOSED SOIL BIOENGINEERING CONSTRUCTION PLAN VIEW

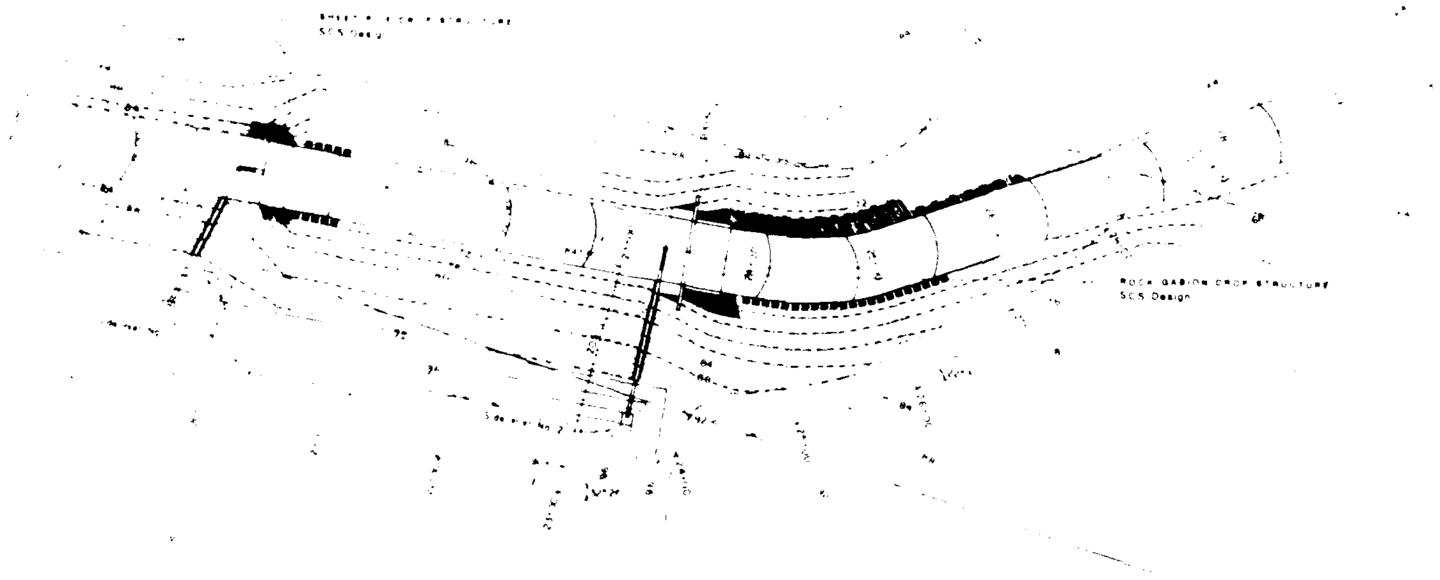
LEGEND

EXISTING EASMENT LIMITS
CONTOUR LINES
FINISHED CUT LINES

PROPOSED SOIL BIOENGINEERING SYSTEMS

BRUSHLAYER
LIVE STAKING
LIVE FASCINE
JOINT PLANTING
VEGETATIVE GEOGRID
LIVE CRIBWALL
BRANCHPACKING

LIVE SILTATION



MAJOR GULLY STABILIZATION USING SOIL BIOENGINEERING TECHNOLOGY

PROPOSED SOIL BIOENGINEERING CONSTRUCTION PLAN VIEW

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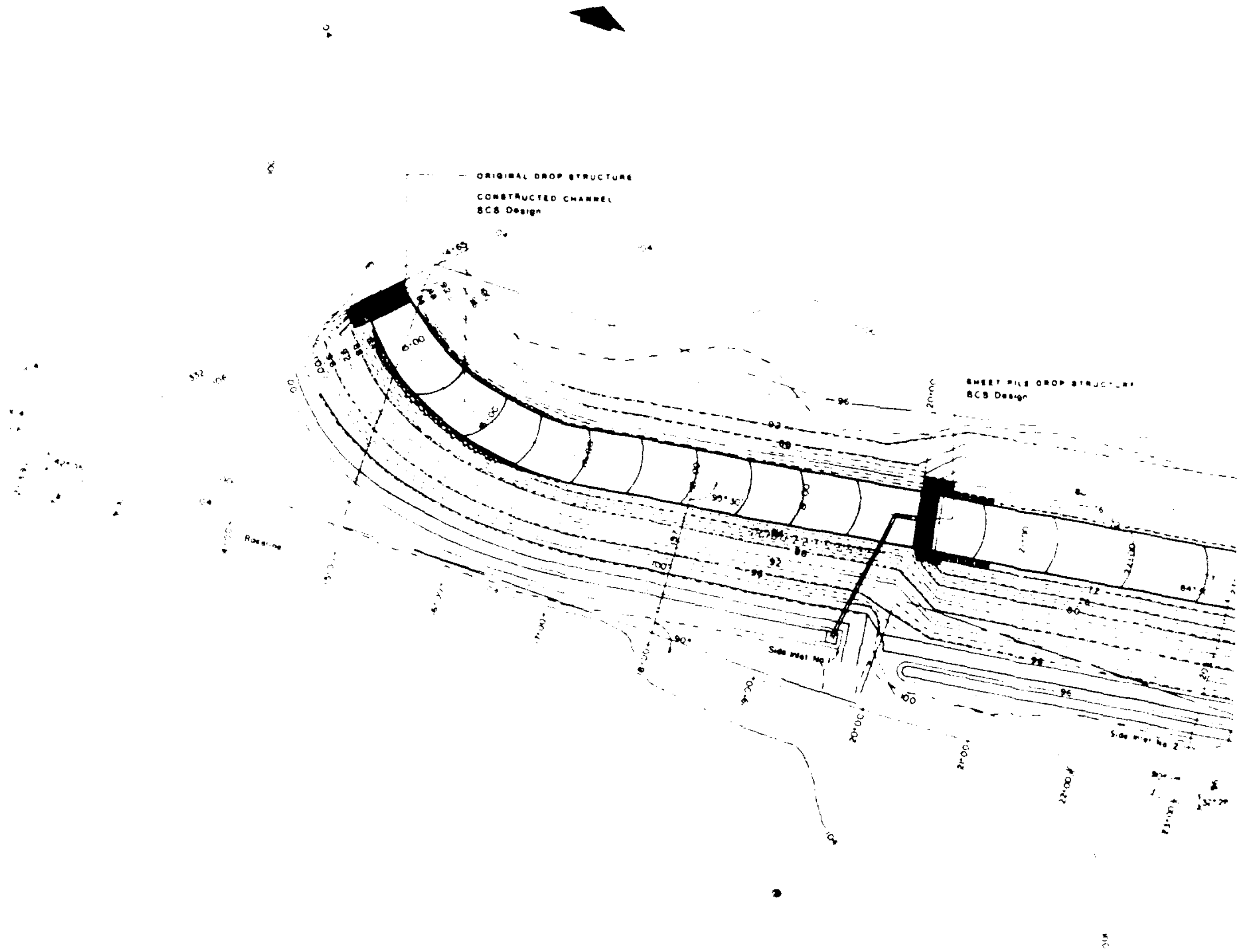


MAJOR GULLY STABILIZATION USING SOIL BIOENGINEERING TEC

AS-BUILT SOIL BIOENGINEERING CONSTRUCTION PLAN VIEW

LEGEND

EXISTING EASMENT LIMITS

CONTOUR LINES

FINISHED CUT LINES

INSTALLED SOIL BIOENGINEERING SYSTEMS

BRUSHLAYER

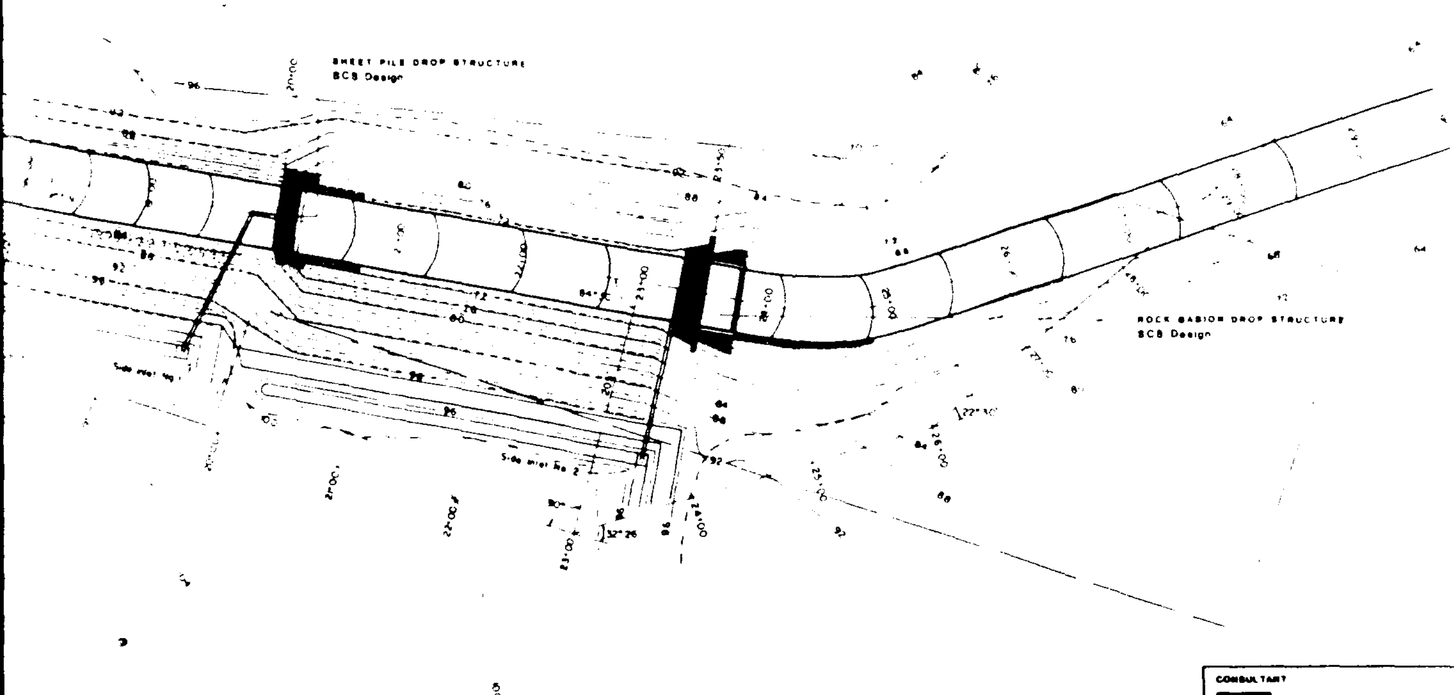
LIVE FASCINE

VEGETATIVE GEOGRID

LIVE CRIBWALL

BRANCHPACKING

LIVE SILTATION



MAJOR GULLY STABILIZATION USING SOIL BIOENGINEERING TECHNOLOGY

AS-BUILT SOIL BIOENGINEERING CONSTRUCTION PLAN VIEW

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THE LIVE SYSTEMS

The live systems recommended for the OLF Silverhill site were developed to first demonstrate living systems, to repair and protect the areas against further soil losses in both the cut and fill slope and bed sections. Finally, they were to serve as a learning tool for the Navy as to how such projects should be handled in the future.

Live Cribwall - See Figure 1. This system was built with timbers, forming an open, box-like structure. As it was built, live plant materials were incorporated at each layer. The live cribwall began to root internally and is expected to root into the bank behind, causing the entire area to become stabilized. The cribwall was placed below the first built grade structure.

Live Fascine - See Figure 2. This is a bundle of live plant material, bound together to form sausage-like structures. They were installed on contour to create a mini dam across the slope face. They were used in between brushlayers to secure sections where extra rooting was desirable and to reduce headcutting up the bank face. These live structures take root along their full length and pump water out of the soil through transpiration.

Brushlayer - See Figures 3 and 4. These live systems were placed in prepared terraces across the cut or fill slope sections. Branches of live, rootable, biotechnically capable plants were placed at an angle into the slope. The terraces were placed on contour across the bank face. In the fill sections, the live plant stock was actually placed up to eight (8) feet into the fill site. In the cut sections, the live branches were actually placed two (2) feet into the slope. This structural reinforcement is intended to increase as the roots develop. The exposed brushy portions of the new brushlayers also function immediately by forming filtered sediment barriers across the slope face. This controls surface runoff, prevents the formation of gullies and encourages natural invasion to occur.

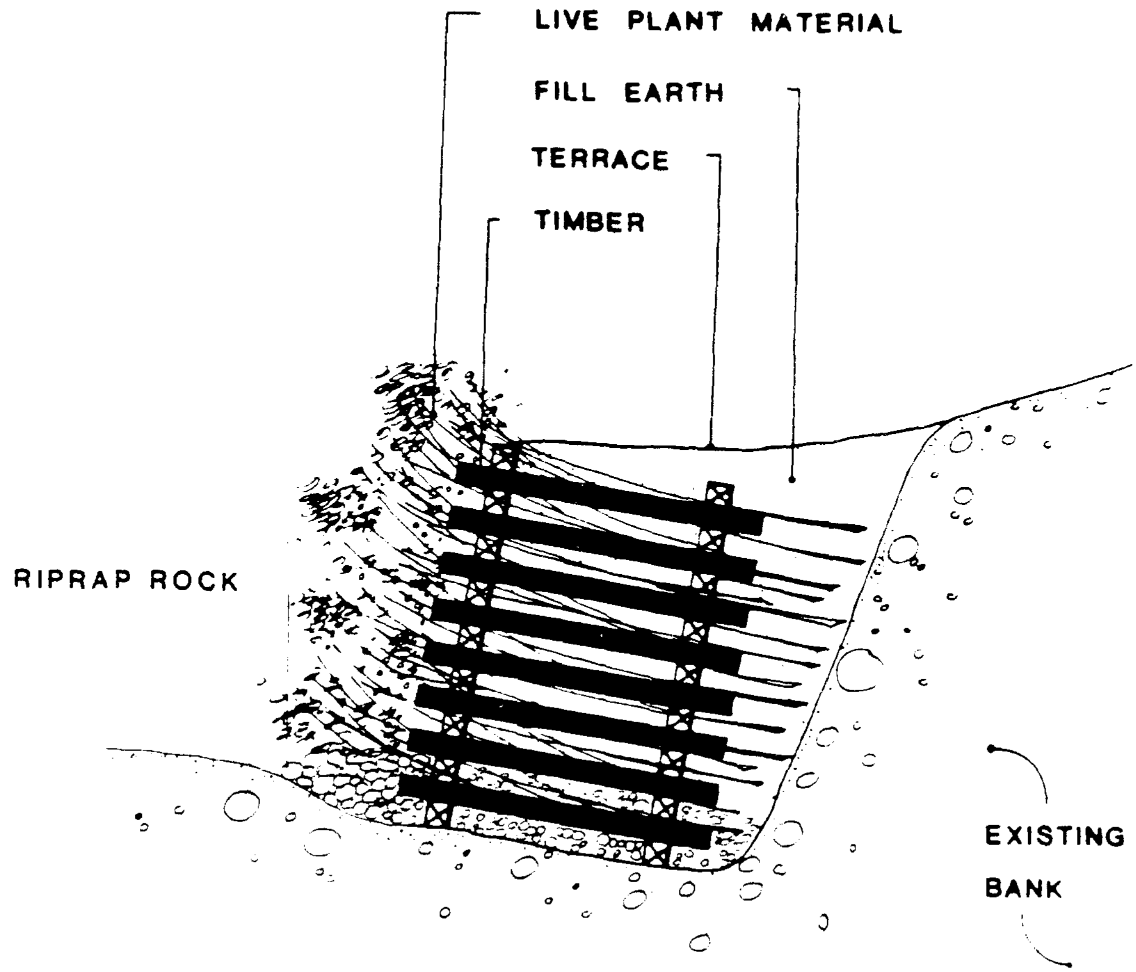
Branchpacking - See Figure 5. The live branches were placed directly in a critical fill area, at an angle in the bottom of the repair fill site. A layer of earth was placed on top of each successive layer to give immediate soil reinforcement and to serve as a brush filter/sediment barrier. This construction is expected to slow the water velocities and capture silts. The live branches are expected to root into the placed fill. This system was used to tie together the left side of the upper existing conventional drop structure and live cribwall into the graded slope.

Live Siltation - See Figure 6. The live branches were placed at an angle directed "downstream" in the bed of the newly shaped channel section. The system gives immediate soil reinforcement and serves to reduce flood velocities and to capture sediment. In properly installed systems the roots are expected to consolidate the soil particles and enhance the stability of the bed.

Live Soft Gabions (Vegetated Geogrids) - See Figure 7. These live systems were placed five (5) feet deep in prepared terraces in the same manner as the previously described brushlayers. In addition to the living brush, the soil layers which are in between the live branches, were wrapped with geotextile material to give added strength in the critical areas.

FIGURES

LIVE CRIBWALL



SECTION

NOTE:

Rooted/leafed condition of the living plant material is not representative at the time of installation.

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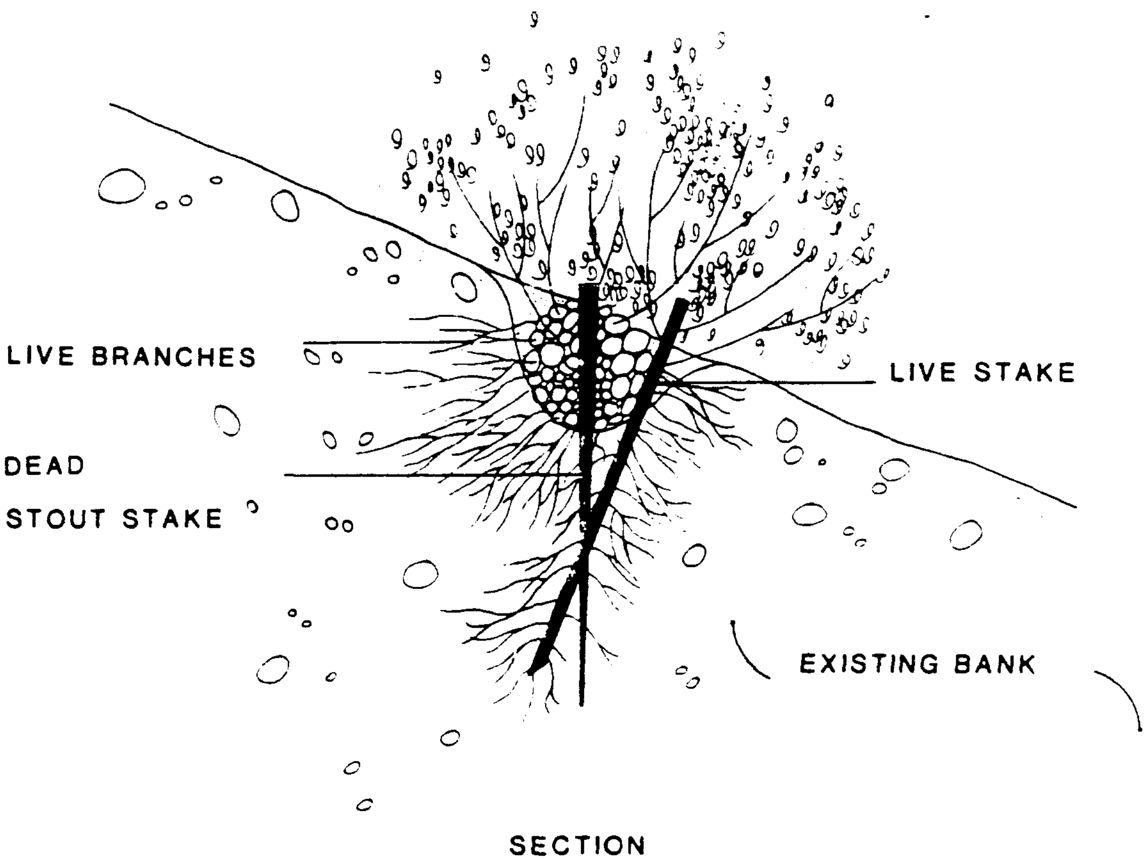
Marietta, Georgia 30060

NTS

FIGURE 1

LIVE FASCINE



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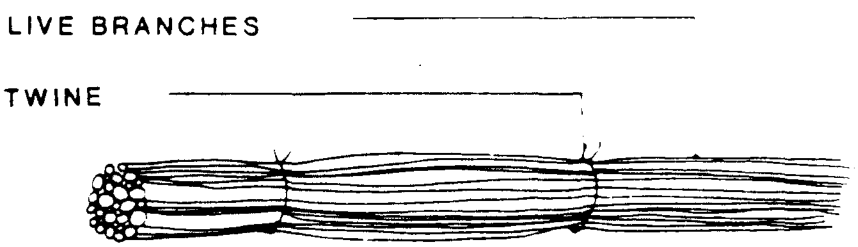

NOTE:

Rooted/leafed condition of the living plant material is not representative at the time of installation.

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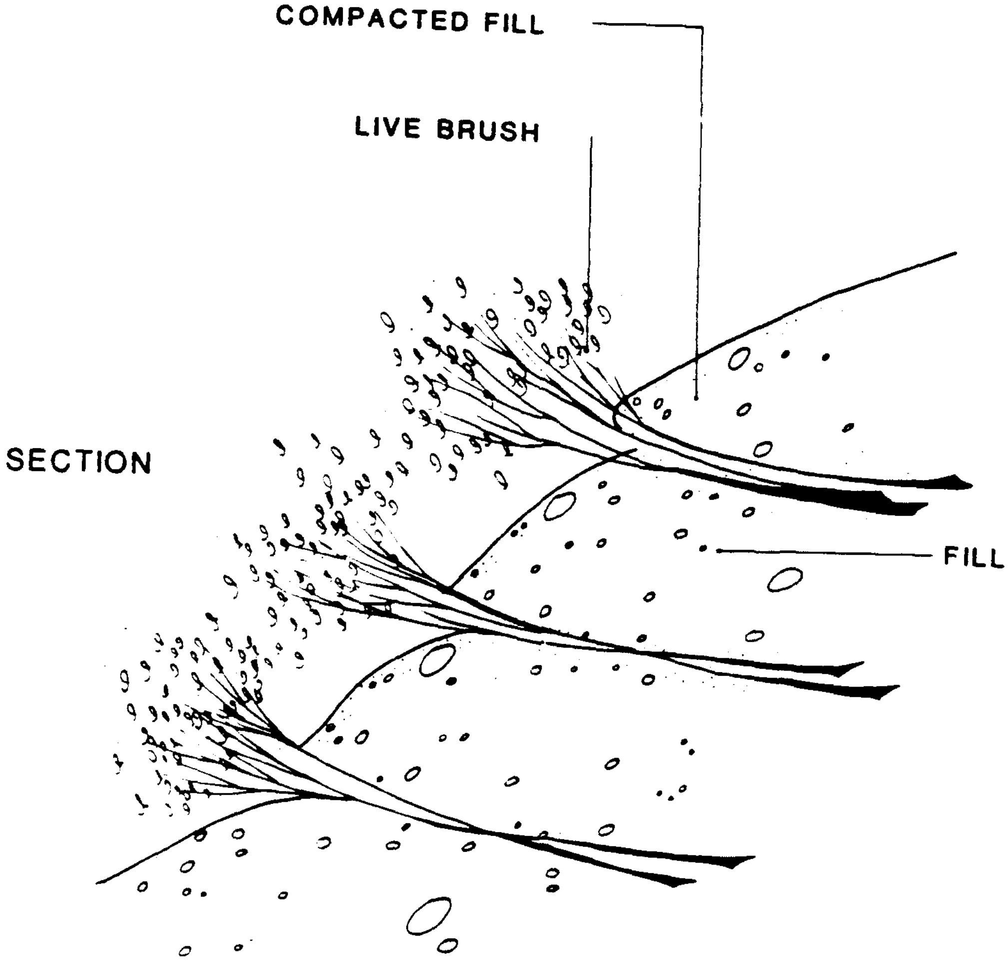
FIGURE 2

Soil Bioengineering Corporation
627 Cherokee Street N.E., Suite 11
Marietta, Georgia 30060

BRUSHLAYER
FILL



NOTE:

Rooted/leafed condition of the living plant material is not representative at the time of installation.

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FIGURE 3

Soil Bioengineering Corporation
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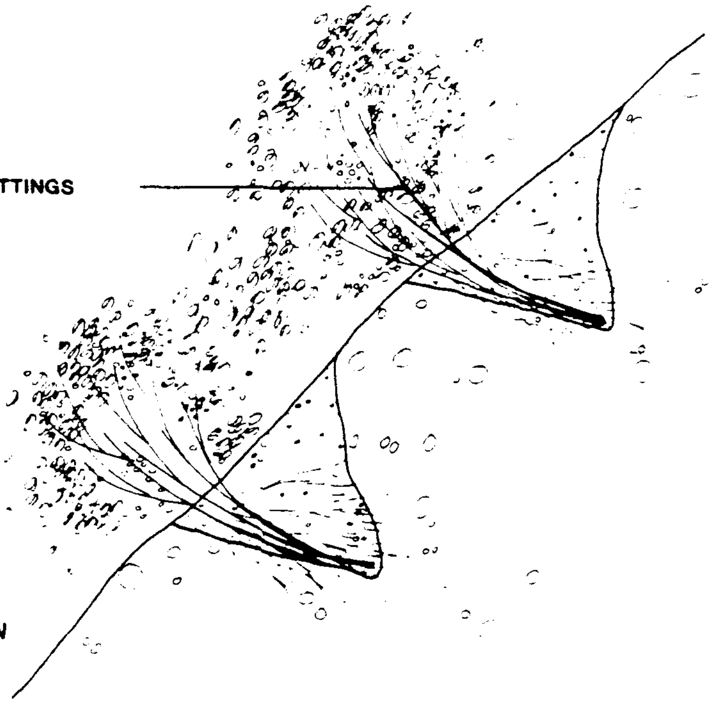
Marietta, Georgia 30060
Telephone (404) 424-0719

BRUSHLAYER
CUT

LIVE CUTTINGS



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Rooted/leafed condition of the living plant material is not representative at the time of installation.

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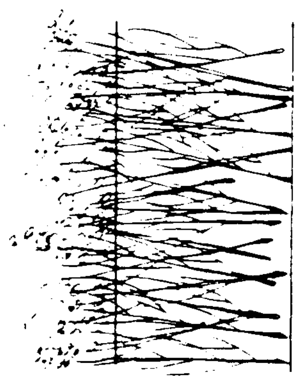

CRISS-CROSS
CONFIGURATION

PLAN VIEW

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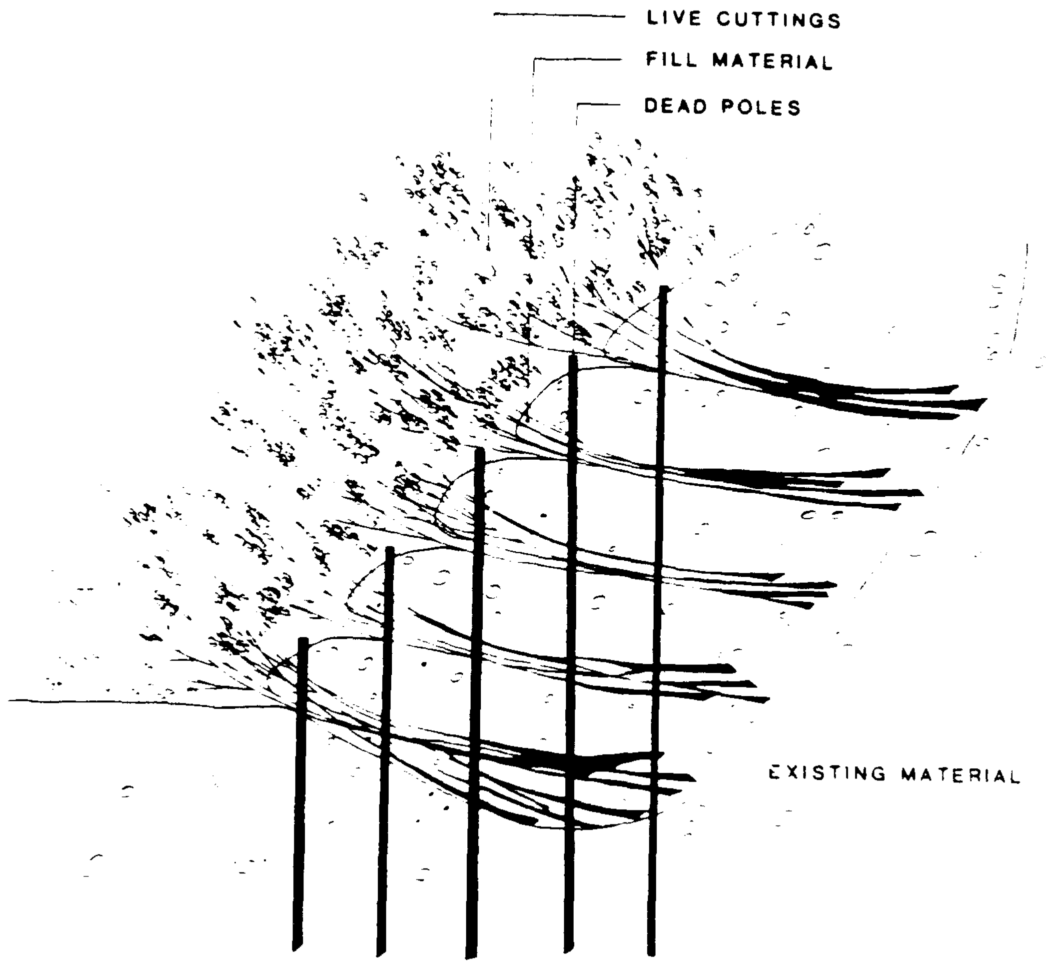
FIGURE 4

BRANCHPACKING



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SECTION

NOTE: Rooted/leafed condition of the living plant material is not representative at the time of installation.

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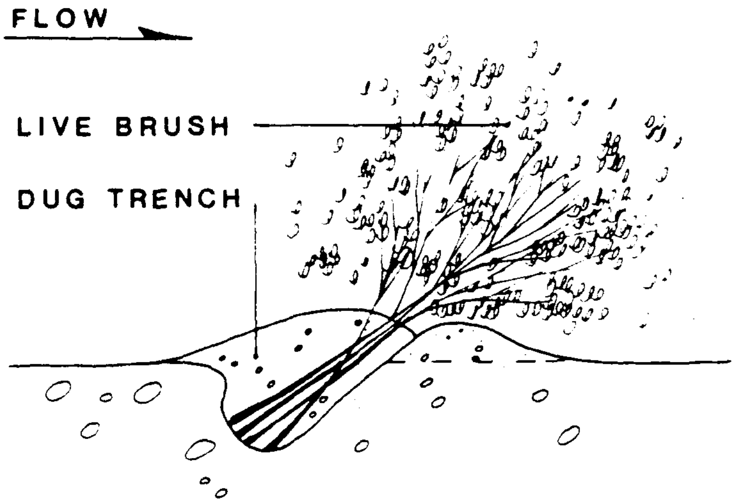
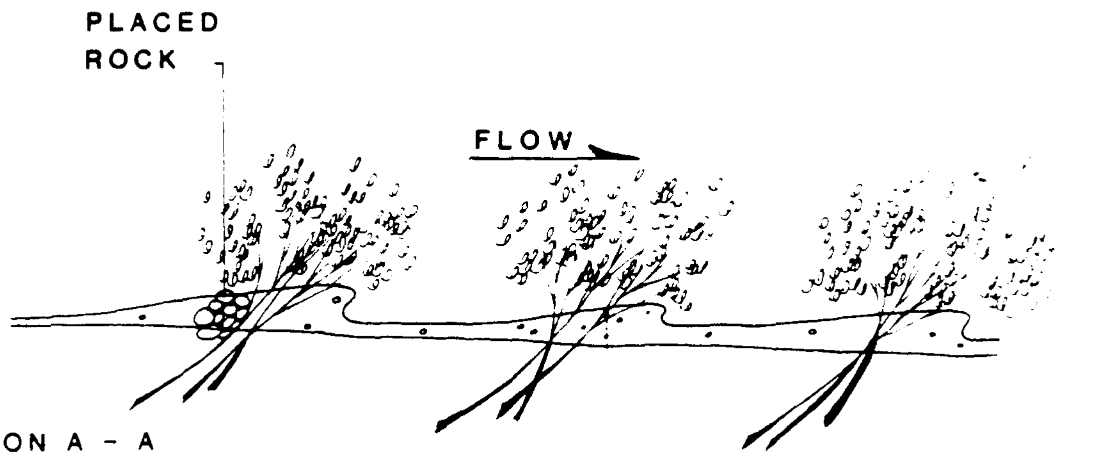
FIGURE 5

LIVE SILTATION CONSTRUCTION





SECTION A - A

NOTE:

Rooted/leafed condition of the living plant material is not representative at the time of installation.

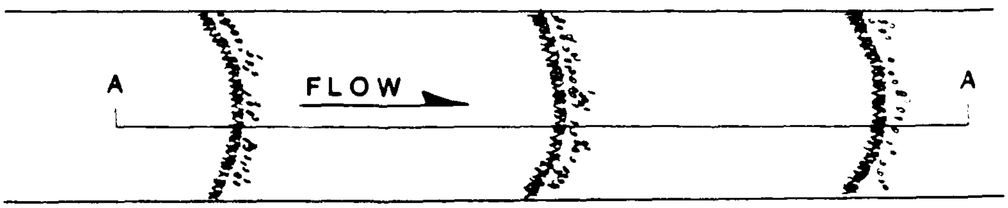


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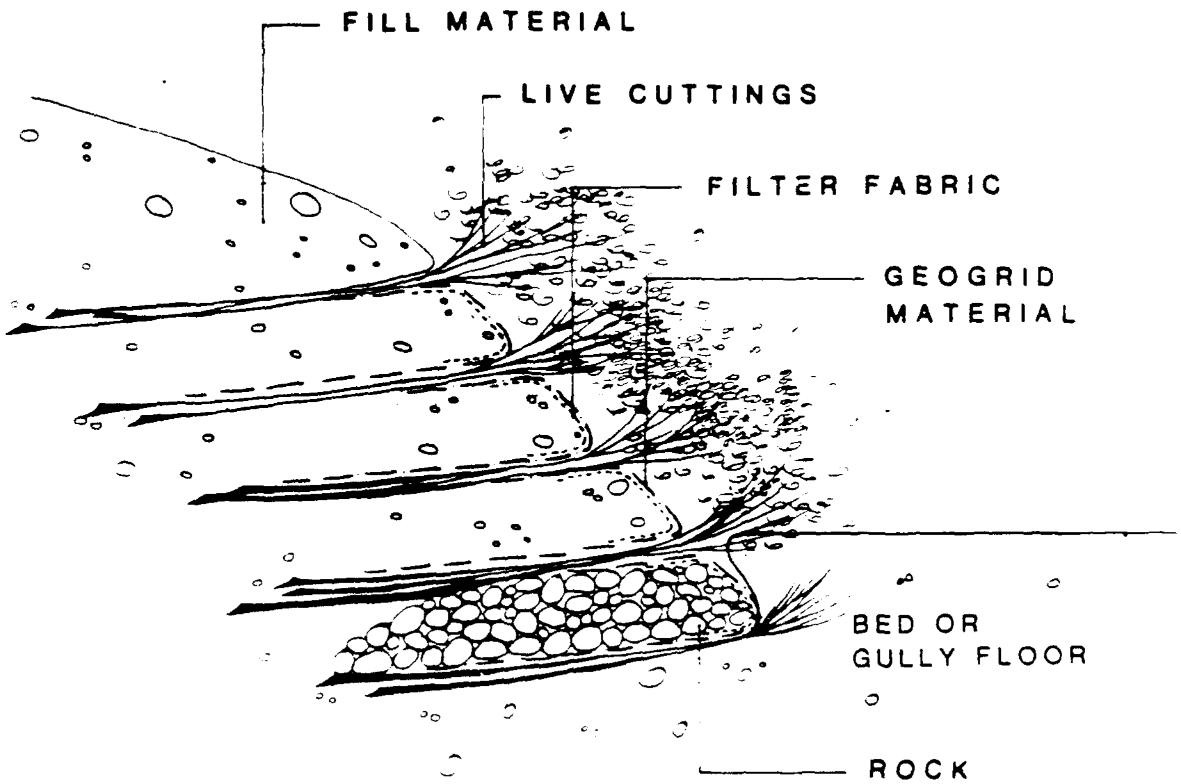
FIGURE 6

LIVE SOFT GABION

SECTION



NOTE:

Rooted/leafed condition of the living plant material is not representative at the time of installation.

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FIGURE 7

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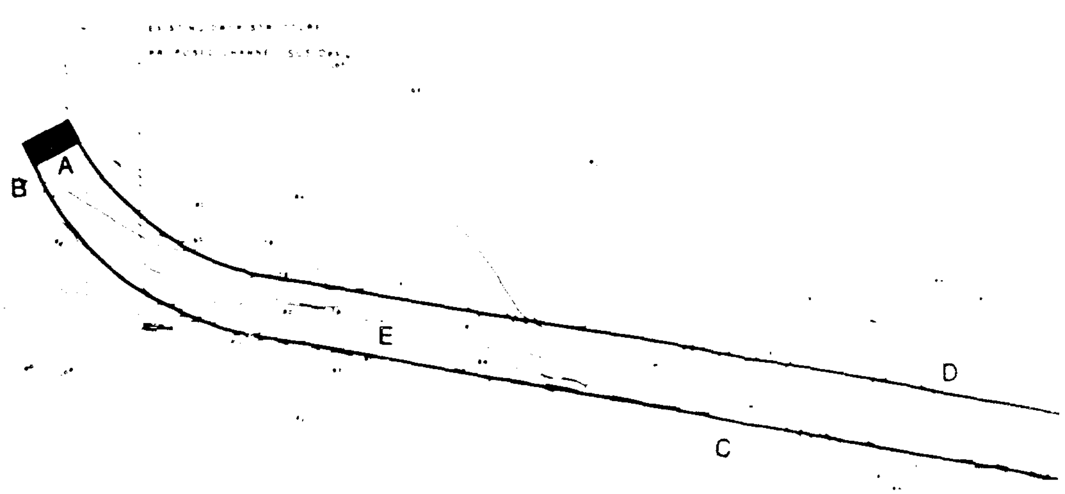
Photographic Sequence Locations



Legerd

Position & Photographs

A. 1, 2, 3 & 4

B. 5 & 6

C. 7 & 8

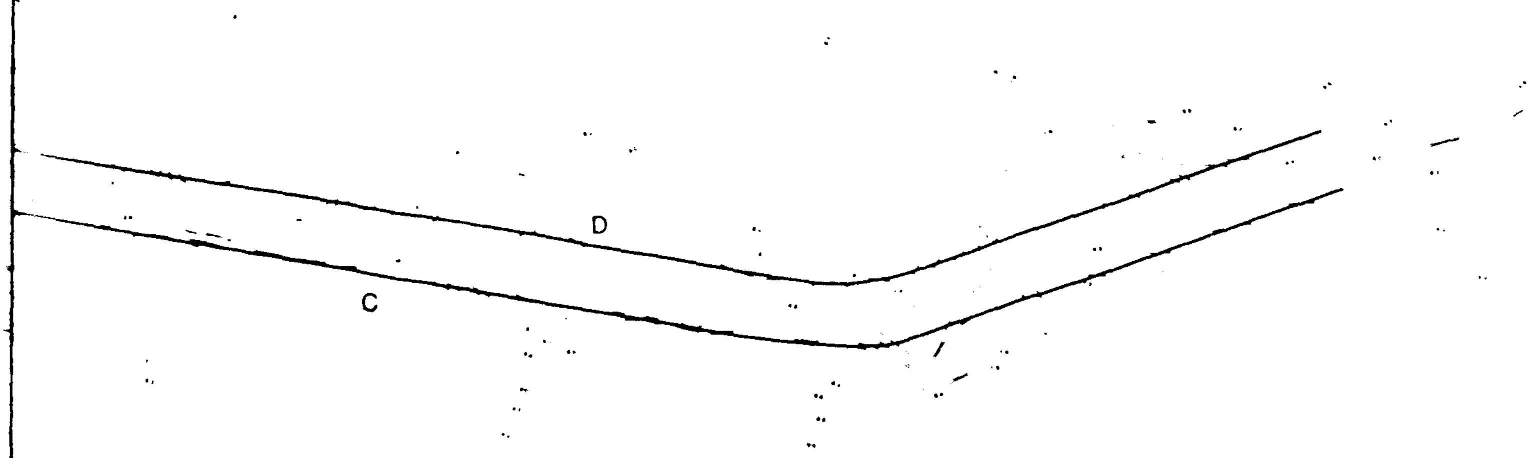
D. 9 & 10

E. 11, 12, 13 & 14

Oblique
Air Photos 15 & 16

MAJOR GULLY STABILIZATION USING SOIL BIOENGINEERING TECHN

Photographic Sequence Locations



ZATION USING SOIL BIOENGINEERING TECHNOLOGY

CONSULTANT

SOIL BIOENGINEERING CORPORATION

SCALE

DATE

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SUBMITTED BY DATE

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PHOTOGRAPHS

PHOTO 1. The area of the drop structure prior to construction. This illustrates the undercutting and side slope erosion headcut problems which threatened the structure

PHOTO 2. The existing drop structure area during the early stages of construction

PHOTO 3. The existing drop structure in the final stages of construction activities. Note the soil bioengineering brushlayers on the left

PHOTO 4. The existing drop structure three (3) months after construction. Note the soil bioengineering brushlayers on the left

PHOTO 5. Left side of the existing drop structure during initial conventional construction

PHOTO 6. Left side of the existing drop structure three (3) months after the soil bioengineering installation

PHOTO 7. The right bank, "downstream" of the first installed drop structure, after soil bioengineering brushlayer installation

PHOTO 8. The right bank, "downstream" of the first installed drop structure, three (3) months after soil bioengineering brushlayer installation

PHOTO 9. The left bank, "upstream" and alongside the second installed drop structure, during construction

PHOTO 10. The left bank, "upstream" and alongside the second installed drop structure, three (3) months after installation of the brushlayers

PHOTO 11. "Downstream" view of the gully during initial conventional construction

PHOTO 12. "Downstream" view of the gully during the soil bioengineering brushlayer installation

PHOTO 13. View "downstream" after the soil bioengineering brushlayer and live siltation systems had been installed

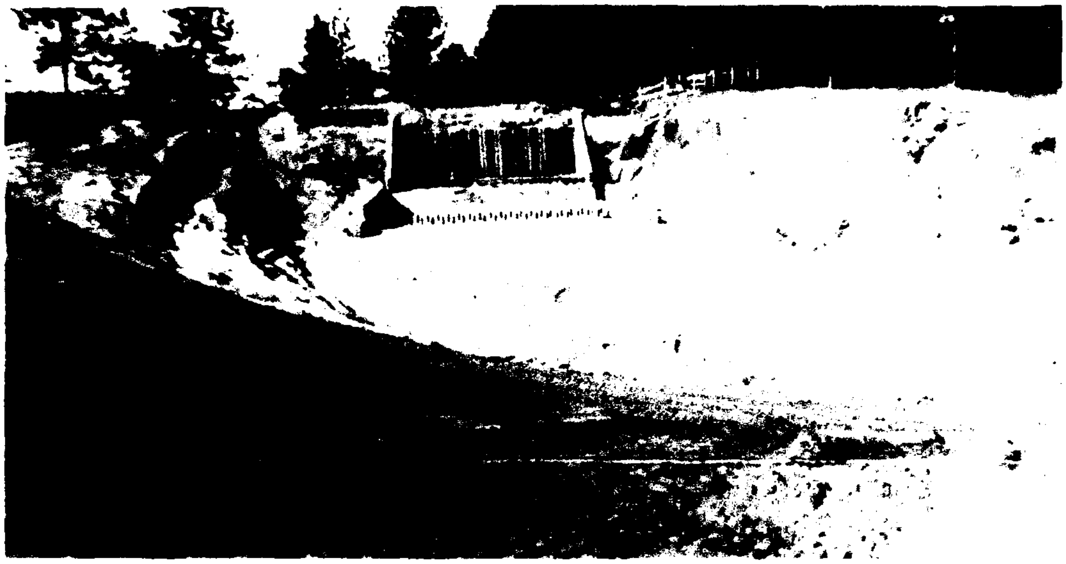
PHOTO 14. View "downstream" of the reconstructed gully/drainage unit, demonstrating the living soil bioengineering units, three (3) months after installation

PHOTO 15. Oblique air photo three (3) months after construction. The photo demonstrates the living soil bioengineering systems, the conventional installations, as well as the airfield drainage source and the pecan orchard

PHOTO 16. Oblique air photo three (3) months after construction

Photo 1.

The area of the drop structure prior to construction. This illustrates the undercutting and side slope erosion headcut problems which threatened the structure.



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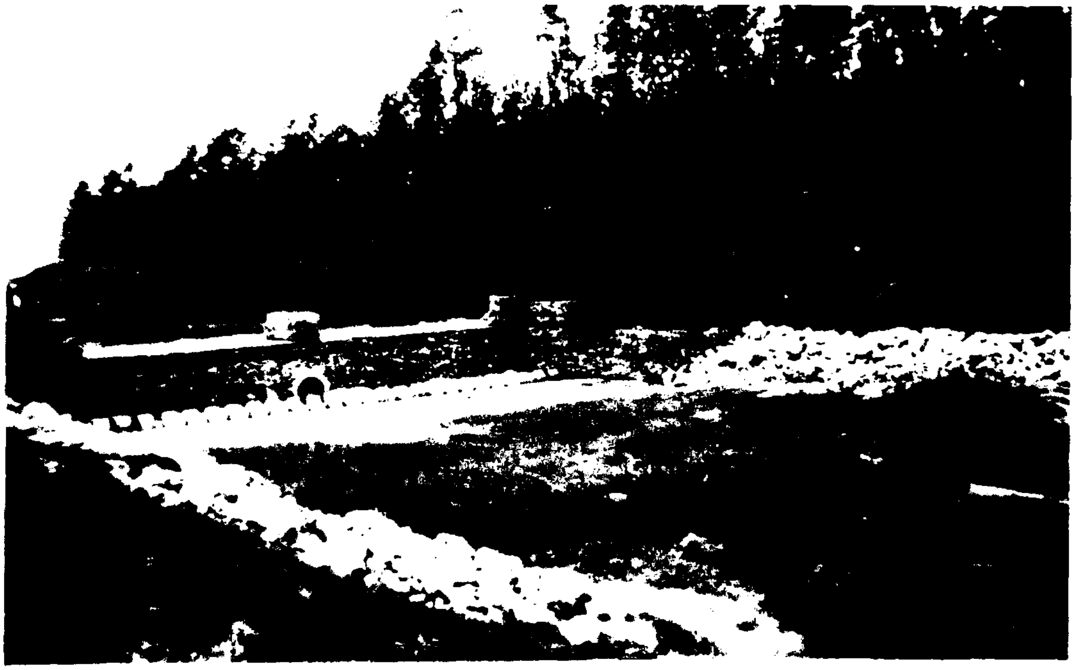

Photo 10. The left bank, "upstream" and alongside the second installed drop structure, three (3) months after installation of the brushlayers.

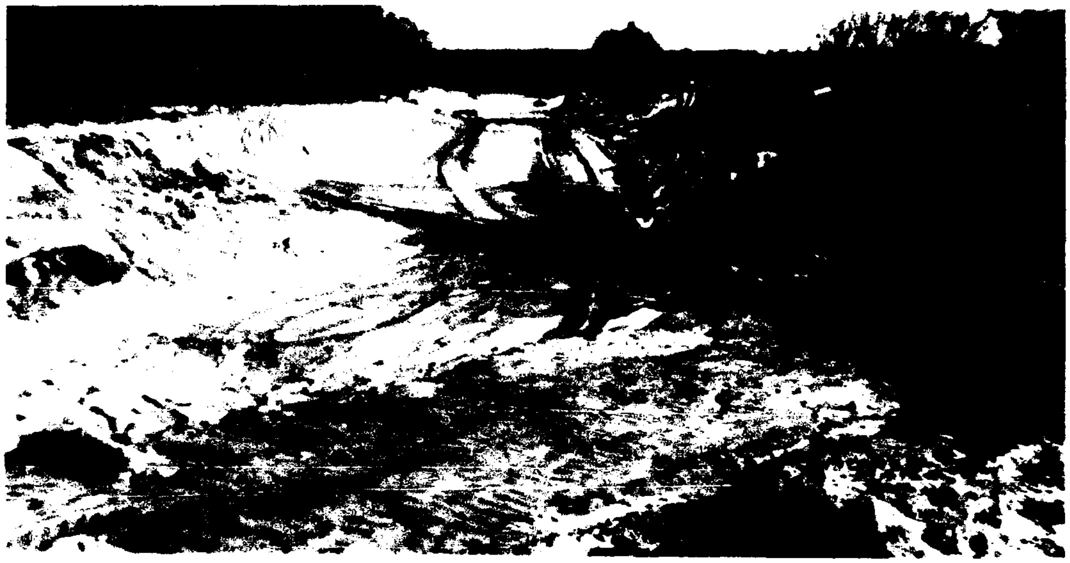

Photo 11. "Downstream" view of the gully during initial conventional construction.

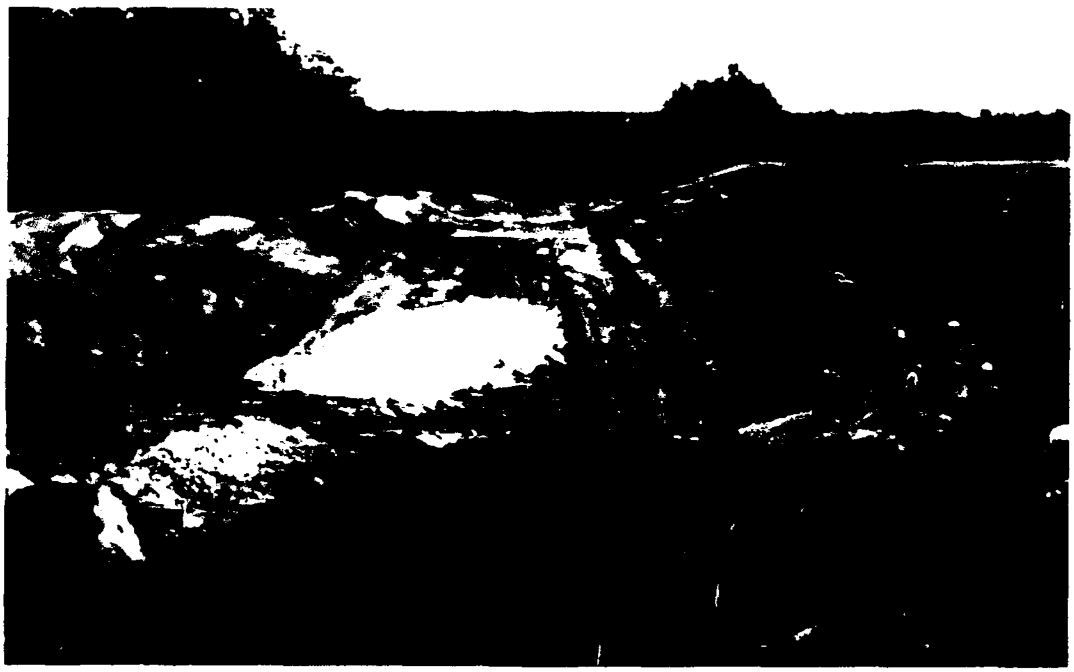

Photo 12. "Downstream" view of the gully during the soil bioengineering brushlayer installation.

Photo 13. View "downstream" after the soil bioengineering brushlayer and live siltation systems had been installed.

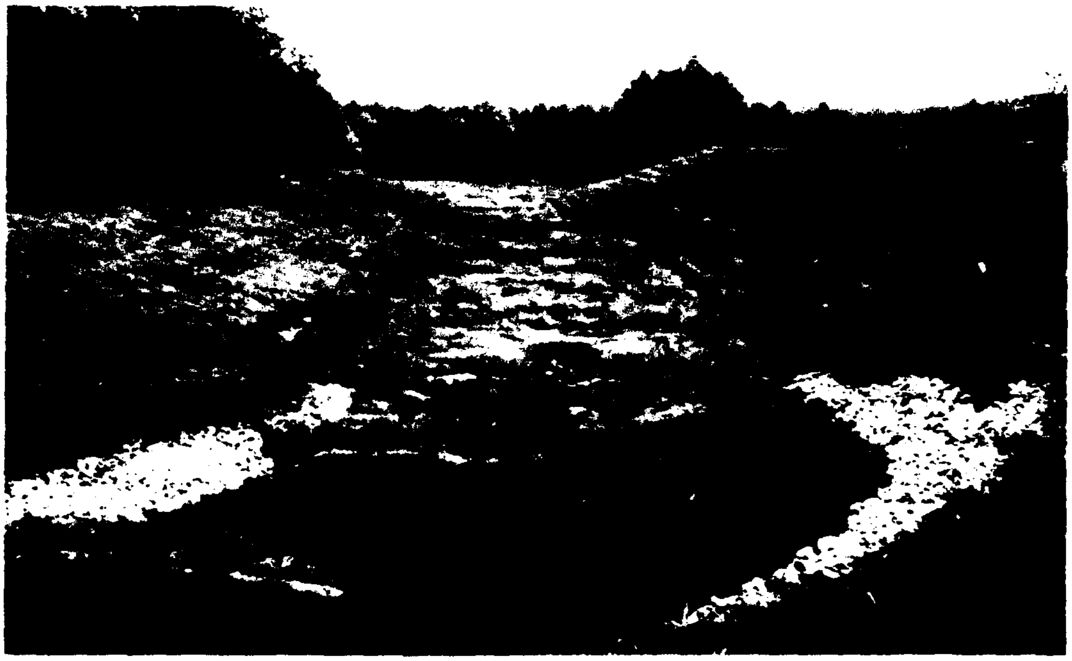

Photo 14. View "downstream" of the reconstructed gully/ drainage unit, demonstrating the living soil bioengineering units three (3) months after installation.

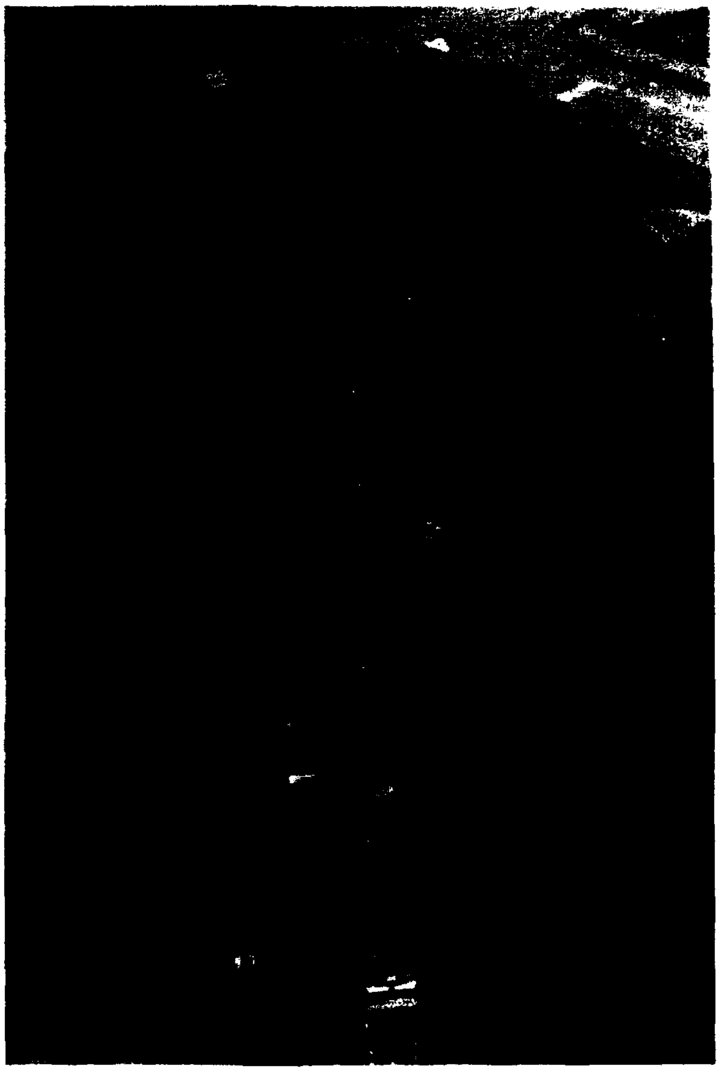

Photo 15. Oblique air photo three (3) months after construction. The photo demonstrates the living soil bioengineering systems, the conventional installations, as well as the airfield drainage source and the pecan orchard.

Photo 16. Oblique air photo three (3) months after construction.

EVALUATION OF SOIL BIOENGINEERING SYSTEM SUCCESS AS IT RELATES TO INSTALLATION AND PROJECT MANAGEMENT

From a mechanical point of view, i.e., considering the ability of the installed branch units to halt surface erosion, the soil bioengineering systems are all performing very well at this time. From a living point of view, those systems which were more deeply installed, have been most successful.

The deep fill brushlayers, the branchpacking sections, the live cribwall units and the live soft gabions (vegetated geogrids) are all doing very well. The extensive deletions (determined by the ROICC) of the fill brushlayers, the shallow placement of the installed cut brushlayers and the sandy soils, coupled with the expected and experienced drought conditions, did not give the cut brushlayer units the success rate that might have been realized (see Table 1).

The live fascine units appear to be alive for approximately twenty (20) to thirty (30) percent overall. These units, however, are of less importance after the first few months of the brushlayer establishment. The cut brushlayers which are very important to the success of the project, are doing somewhat better. Unfortunately, due to their shallow placement, they are clearly suffering. The ROICC made the decision to reduce the depth from the recommended five (5) to eight (8) feet to two (2) to three (3) feet. This is a very shallow depth in sandy, droughty soil conditions. Because of this decision, we do not feel that they will reach the necessary seventy (70) to eighty (80) percent overall survival rate. This should have been a healthy, self-supporting system, but in reality these areas are in great jeopardy. Since they represent the majority of the installed work, the reductions and deletions made by the ROICC may clearly have damaged the project goal.

The live siltation installations in the center of the channel have worked as expected in some sections, but due to poor installation, they have not been able to demonstrate the optimum capabilities of this system.

The brushlayers in fill, the live cribwall units and the live soft gabions (vegetated geogrids) all appear to have achieved a healthy seventy (70) to eighty (80) and in some cases up to ninety (90) percent survival rate at this time. These areas should work well to stabilize the newly repaired drainage site.

The live stakes and the joint planting systems were totally deleted (by the ROICC) and therefore there is no opportunity for evaluation.

The systems that have been the most successful appear to be those that were installed at the greatest depth and those that were installed correctly, with freshly cut branches and in the dormant season. Unfortunately, these are the least representative of the soil bioengineering installations.

Several sections of soil bioengineering work were deleted, by the ROICC, especially on the north bank. Of course, this in itself may serve as a comparison. The south bank, installed with soil bioengineering, suffered no bank failures during or after construction. However, several sections were unwisely changed from fill to very shallow cut brushlayers, which may carry its own set of problems with it, from a living point of view.

The bank with mostly conventional grassing suffered several failures during construction. Additionally, these sections are still eroding and are very sparsely vegetated. We expect that they may contribute to bank failures and sediment load again in the future. The area on the right side (facing "upstream") of the old existing drop structure has already eroded into a hole at the top. The ROICC simply filled this area and covered it with "Hold Gro", a loosely woven paper product. The "downstream" siltation device was heavily damaged at the early stages of construction. Although this was pointed out to the ROICC on-site representative in person, the damage was not repaired. In June, 1988, it still had not been repaired.

TABLE I

Soil Bioengineering System Comparisons
Between Designed and Installed Units

System	Unit	Proposed & Contracted to be constructed	Actually Constructed	Deletion	Addition
Live Stakes	each	5,500	0	5,500	-
Joint Planting	each	3,800	0	3,800	-
Brushlayer Cut	lin.yd.	3,700	3,800	-	100
Brushlayer Fill	lin.yd.	2,100	250	1,850	-
Live Fascine	lin.yd.	690	65	625	-
Live Cribwall	sq.ft.	595	750	-	155
Live Soft Gabion (Veget. Geogrid)	lin.yd.	940	285	655	-
Branchpacking	lin.yd.	330	30	300	-
Live Siltation	lin.yd.	340	340	-	-

SUMMARY

The shining light in this entire project from start to finish has been the Naval Civil Engineering Laboratory (NCEL) group, Port Hueneme, California, that supported the project and the soil bioengineering technology.

A great deal can be learned from the OLF Silverhill project. It is obvious that the failures were imposed on the project. They were not originally designed into it. The decision makers were either unwilling or unable to read and follow the plans and specifications or to listen to the instructions of the experienced on-site Consultants. This inability or unwillingness was rapidly passed on to the construction Contractors.

The project is now completed or partially completed and what has been sown is now being reaped.

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MGT Management
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